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Studies on the development of soil mesofauna in a rubble dump cover

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Summary :

The colonization of a rubble dump by Collembola and Acari was investigated with a caging experiment. Microclimate especially air humidity, influences the development of soil mesofauna in the beginning of colonization, while in the later stages inter- and intraspecific interactions play a major role.

Zusammenfassung : Untersuchungen über die Entwicklung der Bodenmesofauna einer abgedeckten Bauschuttdeponie

Die Bodenmesofauna (Collembola und Acari) der Abdeckschicht einer Bauschuttdeponie nahe Bremen, BRD, wurde im Hinblick auf Besiedlung und mikroklimatische Beeinflussung ihrer Entwicklung mit Hilfe eines Käfigexperiments untersucht. Für die Ansiedlung (0 - 4 Monate) der Bodenorganismen spielt das Mikroklima und dabei besonders die Luftfeuchtigkeit eine ausschlaggebende Rolle, während der weitere Verlauf der Entwicklung (4 - 18 Monate) zunehmend von inter- und intraspezifischen Interaktionen geprägt wird.

Key words : rubble dump, colonization, microclimate, Collembola, Acari.

I. Introduction

Studies on the development of soil mesofauna are of special interest in recultivation research because soil mesofauna plays an important role in the functioning of nutrient cycles and their regulation (EDWARDS *et al.*, 1970) and contributes to the stability of the ecosystem (WEIDEMANN *et al.*, 1982). The first stages of the development of the soil fauna on our research site, the initially bare soils of a covered rubble dump, is characterized by the invasion of faunal elements from surrounding areas and the development of organisms which were transported with the cover material. The development of these faunal elements depends on the specific abiotic conditions on the site. A caging experiment was set up to investigate aspects of immigration and development of soil mesofauna.

One hypothesis to be tested with this experiment was whether some acarine species colonize the site by phoresis (BROCKMANN *et al.*, 1980; HUTSON & LUFF, 1978). The influence of slight microclimatic changes on the development of soil fauna was the second problem to be tested with this experiment.

II. Site, methods and material

The study site, a covered rubble dump, is situated in a marshland area near Bremen, GFR. One bare soil (disturbed soil from excavations etc.), three experimental plots of 1 m^2 each were set up, two of which were covered with cages of 5 mm and 1 mm mesh size, respectively. Plastic boards were driven 20 cm into the soil around the cages to prevent underground invasion. The control plot was situated between the two caged plots, the whole setup covering *ca* 1 x 4 m. Samples (25 cm^2, 100 cm^3) were taken on 3.VI.1980 (t_o) and also 4 and 18 months later from three horizons (0-4 cm, 4-8 cm, 8-12 cm). They were treated for ten days in a Macfadyen-type extractor (final temperature of lower sample surface : 50° C). The obtained fauna consisted of more than 95 % Collembola and Acari. The mesofauna was studied on a group level. Soil data, including temperature, actual moisture content, organic material and pH, were obtained from the same samples.

III. Results

Immigration by phoresis as well as by passive wind drift was thought to be influenced by the cages. Only the sampling after 4 months (10.X.80) may be considered in respect to colonization. Contrary to our assumption, mesofauna abundance increased with reduction of mesh size (Fig. 1). The 1 mm cage, in spite of making phoretic immigration very unlikely, had the highest abundances. The faunal development of this plot originates from faunal elements introduced by wind and /or from survivors in the soil cover, and is influenced by microclimatic changes caused by the cages. The following measurements were made to find the governing abiotic factor(s).

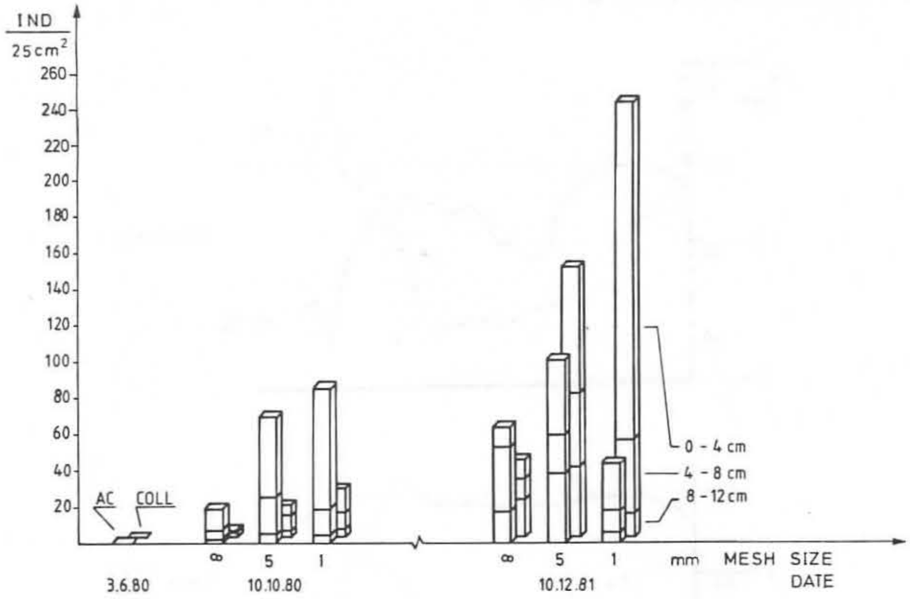

Figure 1 Development of Collembola and Acari abundances in the soil of a covered rubble dump. Caging experiment with control (∞) and mesh sizes of 5 mm and 1 mm. Sample size : 25 cm^2, 100 cm^3. Three horizons : 0-4, 4-8, 8-12 cm.

1. Temperature

The temperature was measured with minimax thermometers in 1cm depth. Within the cages, the minimal and maximal temperatures are lower (the small mesh size being the lowest) and have a slightly reduced amplitude which could be confirmed with a daily record (Fig. 2). The differences are, however, only a few degrees compared to the control.

2. Moisture

The air moisture 1 cm above ground has been measured with electronic microsensors (Kyberna, Bensheim, GFR). Over a diurnal record (23. - 24. VIII. 82), the air under the small mesh size is almost always oversaturated (condensed water on the sensor),

while under the 5 mm cage it is below, but near saturation, and the control fluctuating. The fluctuations are much smaller in the cages than in the control, being smallest in the 1 mm cage (min. r.h. still 90 %; Fig. 2). Rain drops are shattered by the nets to a fine drizzle and in the small meshes a water film is produced through capillary effects, both enhancing evaporation and cooling. Thus, the cage produce their own microclimate. However the soil moisture does not show overt differences. For the two samplings neither the cages nor succession produced an effect and actual soil moistures between 16 and 20 % have always been recorded. A correlation analysis was made to find out whether slight differences in soil moisture content could be responsible for the different abundances in the cages, but gave only for Collembola of the 10.X.80 sample, 4-8 cm, significant results (r = 0.95).

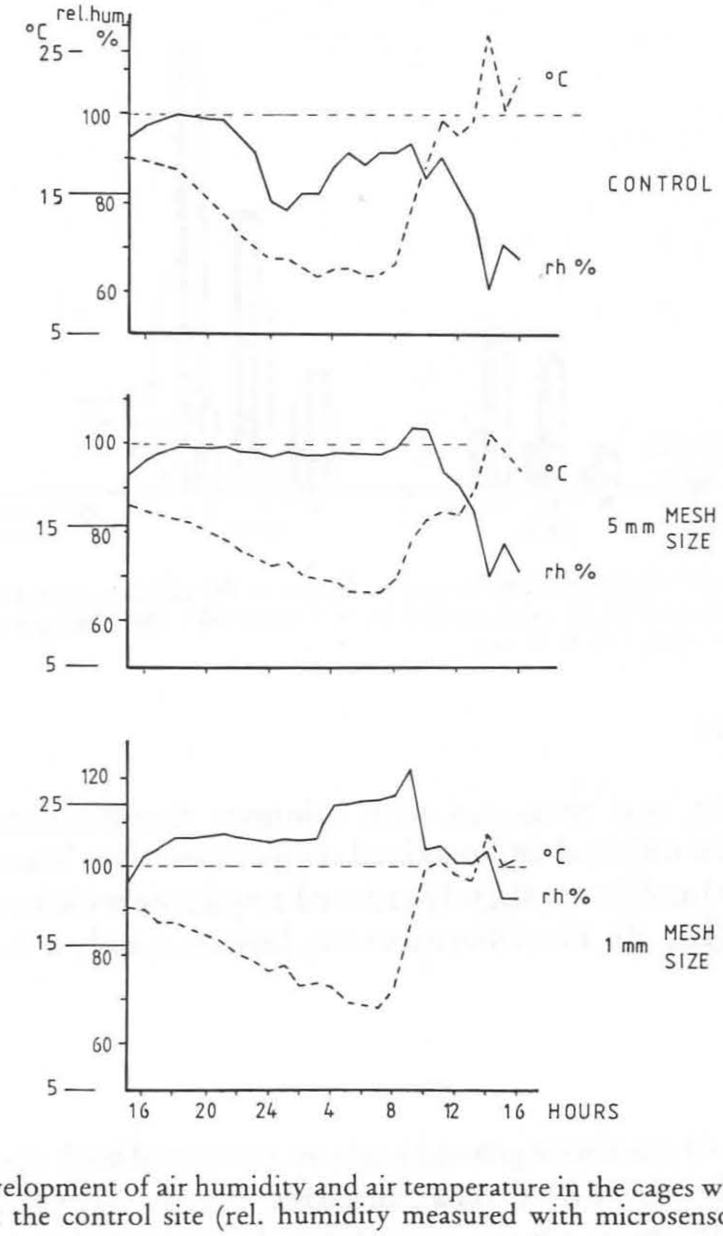

Figure 2 Diurnal development of air humidity and air temperature in the cages with 5 mm and 1 mm mesh size and on the control site (rel. humidity measured with microsensors Kyberna, Bensheim, GFR).

3. Vegetation and organic C

The special microclimate in the cages, however subtle the differences may be, has a strong effect on the vegetation. An obvious increase of cover can be observed with decreasing mesh size which influences the microclimate as a secondary effect. But there is only a slight increase of organic C in the soil under the cages (Table I).

TABLE I

Development of vegetation cover and organic C.

Date	10.X.80			10.XII.81		
Mesh size (mm)	∞	5	1	∞	5	1
Veg. cover (%)	20	30	60	95	80	100
Org. C (0-4 cm) (%)	2.3	2.2	2.5	2.6	2.7	2.8

The high abundances of Collembola in the sample of 10.XII.81 might to some extent be due to the higher organic C.

4. Soil mesofauna

The increase of Collembola and Acari is attributed mainly to microclimatic effects. Exclusion of surface dwelling predators occurs to a certain extent and might play a role in the regulation of the mesofauna. Mesofaunal predators like Gamasida represent nearly 20 % of the Acari (0-4 cm) in the 1 mm cage, compared with less than 5 % in the corresponding 10.XII.80 sample. But these predators do not correlate with the abundance of Collembola, which they prey upon (KARG, 1968). Oribatids, being slow colonizers (WEIGMANN, 1982), are only found occasionally. Nanorchestidae represent up to 60 % in the samples of 10.XII.80. The collembolan community of the 10.XII.82 samples under the small mesh size cage is characterized by a high proportion of juvenils. The dominant adult is *Isotoma notabilis* (0-4 cm), a species indicating moderate conditions. On the control site, *Tullbergia krausbaueri* is dominant (0-4 cm), being a pioneer with high constancy even under unfavourable conditions (DUNGER, 1968).

A detailed taxonomic investigation is under progress and will give more information concerning the effects of the cages.

IV. Discussion

Research on microclimatic influences on the soil mesofauna has mainly concentrated on correlations between soil temperature or soil moisture and the abundance of

Collembola and Acari (HÜTHER, 1961; VANNIER, 1970; KACZMAREK, 1973; HARTNIGK-KÜMMEL, 1982). Mostly, only weak or no correlations were documented. However, TADROS (1981) found a doubling of the soil fauna as an effect of covering the soil with plastic tunnels. For the distribution of oribatids, the range of moisture tolerance is probably a major factor (MITCHELL, 1979; METZ, 1971), and most Collembola species require relative humidity near saturation (LORING, 1981).

The cages, like dense vegetation, provide a high air humidity. Air moisture near saturation with medium humid soils is positive for the development of soil mesofauna rather than maximal soil moisture, which may even lead to waterlogged pores.

Humidity is very likely to be an indirect factor, interacting inseparably with temperature and food (MITCHELL, 1979; NOSEK, 1981). The observed weak correlations of mesofaunal abundances with organic C content indicate, that aside from food quantity its quality is of great importance (as will be elaborated on in a later paper). By extrapolation from the data shown in Fig. 1 we may conclude that for the Acari a carrying capacity of 60 - 70 ind./25 cm^2 (0 - 12 cm) is reached within the 18 months of development, whereas the system remains exploitable for the Collembola. This is supported by data from adjacent areas of the dump, where abundances of 70 - 150 Acari (25 cm^2, 0 - 12 cm) and 110 - 270 Collembola (25 cm^2, 0 - 12 cm) are found.

V. Conclusion

The data suggest two conclusions :

- for the establishment of the biocoenosis of soil organisms (Berlese-fauna), microclimate, especially air humidity, plays a very important role;
- as the « biocoenotic connexion » increases, inter- and intraspecific regulation mechanisms become more and more important.

An improvement of microclimate (in the sense of higher humidity and reduced temperature amplitude) facilitates the establishment of the soil mesofauna. This improvement can partly be achieved by recultivation with grass, which has a similar primer effect on the soil fauna (WEIDEMANN & KOEHLER, unpublished). Grass recultivation should, however, be succeeded by a complex phytocoenosis to enhance the complexity of the system.

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